IEEE International Ultrasonics, Ferroelectrics, and Frequency Control 50th Anniversary Joint Conference

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ABSTRACT REVIEW

Section Preference: Frequency Control Group 2 - Oscillators Synthesizers & Noise
Presentation Preference: oral
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ABSTRACT TITLE
Phase Noise Measurement of Low-Power Signals

ABSTRACT TEXT

Traditionally, phase noise is measured by comparing two signals of the same frequency, one of which is taken as the reference, using a saturated mixer as the phase-to-voltage converter. Typical low-noise double-balanced mixers require a power of 5-15 dBm to saturate. In some cases of interest, none of these signals has sufficient power. In the case of signals distributed over optical fibres, for example, the output power of a photodetector can be -20 dBm or less, requiring further amplification before feeding into the mixer. Yet, amplifiers flicker, which turns into the main measurement limitation at low Fourier frequencies. The flicker noise of actual microwave amplifiers is in the range of -100 to -110 $dBrad^2$/Hz at f=1 Hz off the carrier.

We have discovered that the amplifier flickering can be strongly reduced by feeding into the amplifiers the sum and the difference of the two signals, instead of merely amplifying them. The two signal must be matched in amplitude and phase for the difference to be close to zero. Neither correlation or averaging are required to reduce the flicker noise, for a clean signal proportional to the instantaneous value of the phase is available in real-time at the mixer output. On the other hand, white noise and other linear additive random fluctuations can not be reduced in this way.

The experimental demonstration goes as follows. First, two signals of frequency ν_0=10 GHz and power P_0=-20 dBm, obtained by splitting the output of a single synthesizer, are amplified and detected. The amplifier noise results in a residual flicker of -106 $dBrad^2$/Hz at f=1 Hz. Then, the sum and the difference of the same signals are amplified and detected. Using the same components, the residual flicker is of -130 $dBrad^2$/Hz at f=1 Hz. This improves by 24 dB upon the first configuration.

The analytical proof and the physical interpretation are surprisingly simple.

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KEYWORDS
Phase noise
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